MANUFACTURING EXTENSION AND PRODUCTIVITY DYNAMICS

By

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CES 98-8 June 1998

Abstract

This paper presents results from an investigation of the effects of manufacturing extension on the productivity dynamics of client plants. Previous econometric studies of manufacturing extension had very little time series information. This limited what researchers could say about the relative timing of extension services and performance improvements. In turn, this makes it difficult to attribute performance improvements to the receipt of extension services. In this paper, I use a panel of client and nonclient plants to more carefully analyze the dynamics of extension and productivity. The results suggest that the timing of observed productivity improvements at client plants is consistent with a positive impact of manufacturing extension. Estimated program impacts are within the range of those found in previous studies.

Keywords: Manufacturing Extension, Program Evaluation, Panel Data

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This research was funded by the National Institute of Standards and Technology's Manufacturing Extension Partnership. I would like to thank Betsy Bury, Tim Dunne, Bob LaLonde, Don Siegel and seminar participants at the '97 WEA meetings in Seattle, the '97 IAES meetings in Philadelphia, the '97 Georgia Tech Workshop on Industrial Modernization and the '98 ASSA meetings in Chicago for helpful comments. Any findings, opinions or conclusions expressed here are those of the author and do not necessarily reflect the views of the Census Bureau or NIST.

I. INTRODUCTION

In recent years, a consortium of state, local and federal agencies have created a nationwide network of manufacturing extension centers designed to help the nation's 380,000 small and medium sized manufacturers (SMEs) improve productivity and become more competitive. The premise behind manufacturing extension is that smaller manufacturers have failed to adopt modern production technologies and business practices at the same rate as their larger counterparts. Proponents of manufacturing extension argue that this explains the persistent performance gap between small and large manufacturers (see National Research Council, 1993). Because SMEs form an important link in the supply chain, they further argue that this performance gap hinders the global competitiveness of the entire U.S. manufacturing sector. Manufacturing extension centers are intended to provide SMEs with unbiased information on modern technologies and business practices that the market has failed to deliver.

As the name suggests, manufacturing extension is modeled loosely on agricultural extension. Locally based manufacturing extension centers perform education and outreach much like county extension agents do. Following an assessment of a plant's needs, a center might then contract with the plant to provide technical or business assistance,[1] or it may direct the plant to consultants or vendors that can help the plant. Even though they are part of a nationwide network, the operation of individual centers varies greatly.

Federal support for manufacturing extension is handled through the National Institute of Standards and Technology's (NIST) Manufacturing Extension Partnership (MEP). Several states have operated extension centers for decades. However, the creation of the MEP in 1989 spurred rapid growth in manufacturing extension programs around the country.[2] In 1995, federal support for manufacturing extension was $138.4 million, up from $6.1 million in 1988 (see GAO, 1995). Since federal support must be at least matched by state and local funds, total expenditures on manufacturing extension activities in the U.S. are much larger.

Naturally, in this time of tight budgets, policymakers want to know if the tax dollars spent on programs, such as manufacturing extension, produce the desired benefits. As part of its enabling legislation, NIST/MEP was directed to evaluate its activities and demonstrate their effectiveness. Although several papers (see Jarmin, forthcoming, Shapira and Youtie,

[1] Typical services provided by centers include changes in plant layout, process redesign, software selection, preparing plants for ISO-9000 certification and marketing assistance. See NIST (1997) for a collection of case studies about individual projects.

[2] See Feller, 1997, GAO, 1995 and National Research Council, 1993 for more details about the development of manufacturing extension programs.

1997, and Nexus Associates, 1986) demonstrate that client status is associated with increases in productivity, none have shown that extension services caused these increases.[3]

The problem is that researchers never observe what a client plant would have done had it not received assistance from a manufacturing extension center. Thus, researchers must try to replicate this experiment, albeit imperfectly, by either comparing client performance before and after receiving services or by comparing the performance of client plants to a control groups of nonclient plants. Unfortunately, we can not observe and control for all of the factors that, in addition to participating in manufacturing extension, influence plant performance. If some of these unobserved factors (e.g., managerial quality) are correlated with client status, then typical measures of program impact may be biased. This problem is typical in cases where participants are allowed to “self select” into the program being evaluated.

The best way to get around this problem is to randomly assign plants to treatment (i.e., those that receive extension services) and control groups. If this is done, then we can reasonably assume that the only systematic difference between the two groups is client status,

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[3] See Jarmin and Jensen (1997), Shapira, Youtie and Roessner (1996) and Feller, Glasmier and Mark (1996) for surveys of studies evaluating manufacturing extension.

and can then conclude that any observed differences in their performance must be attributable to program participation.

Unfortunately, controlled randomized experiments are often not a feasible option for evaluating programs, such as manufacturing extension. Therefore, we must use nonexperimental data. There is a large literature, especially in the area of job training, that discusses evaluating programs with nonexperimental data (see Heckman and Robb, 1985 and Heckman et. al., 1987).

This literature highlights several methods used to obtain selection bias free estimates of program impacts. These include: i) using instrumental variables, ii) making functional form assumptions or iii) making error structure assumptions. In cases where panel data are available, the most widely used solution is to assume that the error structure in models of program impact have permanent and transitory components. The permanent component is an individual or plant fixed effect. The assumption is that the unobserved variables (e.g., ability in individuals and managerial ability in plants) causing the selection bias are fixed over time for individuals and plants.

Luria and Wiarda (1986), Nexus Associates (1986), and Shapira and Youtie (1997) have employed fixed effect (difference) estimators and Jarmin (forthcoming) has used both fixed effects and instrumental variable approaches to estimate the impact of manufacturing extension on client productivity. However, none of these studies had more than two time series observations per plant.

This raises two issues concerning the robustness of the results of these studies, which generally find a positive association between manufacturing extension and improved plant performance. Namely, fixed effects estimators are most effective in controlling for unobserved heterogeneity when there are several time series observations per plant. Second, the current studies do not deal adequately with the issue of the timing of performance improvements relative to the receipt of services. For example, Jarmin (forthcoming) finds evidence that manufacturing extension clients exhibited more productivity growth between 1987 and 1992 than did non-clients controlling for a number of a factors including selection bias. What is not known is when the performance improvements occurred. If they happened towards the beginning of the period, before most client plants received assistance, then it is very likely that the estimated impact of manufacturing extension services is spurious.

For this paper, I constructed a panel data set with annual data for 726 client and 5818 nonclient plants from 1987 to 1993 and I use it to compare the productivity dynamics of clients and nonclients. The longer panel allows me to more fully control for unobserved differences (e.g., managerial ability) between client and nonclient plants that may bias estimates of program impact.

The panel data set also permits a more careful analysis of the relative timing of service provision and performance improvements. The results indicate positive program impacts with estimates that lie within the range of those from previous studies.

II. DATA

The data used here are from 2 sources. First plant level production data are taken from the Census Bureau’s Longitudinal Research Database (LRD). The LRD is constructed by linking plant level data from the Censuses and Annual Surveys of Manufactures.[4] Due to its comprehensive and longitudinal nature, the LRD is, perhaps, the best data set available for evaluating the impact of government programs on manufacturing establishments. Second, manufacturing extension client data come from nine manufacturing extension centers located in three states. NIST/MEP arranged to have these centers provide client records on a confidential basis.

All the primary data items used in the analysis below are taken from the LRD. The client records are used to identify which plants in the LRD received extension services and when. To

[4] The LRD and other micro data sets are housed at the Census Bureau’s Center for Economic Studies (CES). These data are confidential and can be accessed only by Special Sworn Employees (not necessarily Census Bureau employees) at CES or at Research Data Centers in Boston or Pittsburgh. Jarmin (forthcoming) also uses the LRD to analyze the impact of manufacturing extension.

identify extension clients in the LRD, I matched client records to the Standard Statistical Establishment List (SSEL) using names, addresses and other information shared across the two data sets[5]. The nine extension centers provided just under 12,000 project level records from 4,185 establishments. I was able to match 2,977 (or 71.1%) of these establishments to the LRD (via the SSEL).

In order to compare the productivity dynamics of extension clients to nonclients, I examine a panel of plants that were in the LRD in 1987 and each year of the 1989 to 1993 ASM panel.[6] In the three states, in which the nine extension centers operate, there are 5818 nonclient plants that meet this requirement. Also, 726 client plants meet this and the additional requirement that they had completed at least one project before the end of 1993. Approximately 69.3% of client and 63.3% of nonclient plants also appear in the LRD in 1988.

Restricting attention to plants in the LRD with annual data yields a sample that is not representative of either the client or nonclient establishment populations. The plants examined in this paper are considerably larger and more productive than the

[5] For more details on the matching process see Jarmin (forthcoming). The SSEL is used since the LRD does not contain names and addresses for matching. The LRD and the SSEL share common establishment identifiers that facilitate linking the matched client records to the LRD.

[6] The ASM is a rotating five year panel. All plants with more the 250 employees are included in the ASM with certainty. A probability sample of smaller establishments is also surveyed. However, noncertainty plants can not be selected in to consecutive ASM panels.

average plant. Thus, one should be careful to note that estimates of program impact obtained from this sample may differ from what would be obtained if we had similar data for the entire manufacturing establishment universe. This is not a critical problem, however, since estimating the overall impact of manufacturing extension is not the goal of this paper. Recall, the primary goals of this analysis are to compare alternative fixed effects estimators and to examine the timing of performance improvements relative to the receipt of program services. I believe that the data set used here is the best one currently available for these purposes.

III. Empirical Model and Descriptive Results

The general empirical framework for examining the impact of extension services on the productivity dynamics of client plants is the following production function

$$Y_{it} = f(Ext_{it},\ K_{it},\ L_{it},\ M_{it},\ t,\ \varepsilon_{it}) \tag{1}$$

where i and t index plants and years, respectively. Output, Y, is measured in the LRD as the total value of shipments adjusted for changes in inventories and deflated using 4 digit NBER deflators[7], M is material and energy inputs (also deflated by 4

[7] See Bartelsman and Gray (1995) for a description of the NBER deflators.

digit deflators), K is the capital stock constructed using the perpetual inventory method, L is the total number of employees and g is an error term.

Client status is measured by Ext_{it}. In previous studies of manufacturing extension client status was measured simply as a dummy variable that indicated whether a given plant is a client or not.[8] This measure is appropriate when the data are limited to one observation pre-extension and one observation post-extension. In the present case, however, multiple observations are available for client plants both before and after they participate in the program. A simple client dummy would, therefore, impart client status to many plant year observations that predate program participation. The project records provided by the extension centers include the start and end dates of each project. Thus, I can tell whether a plant partipated in manufacturing extension during any given year. I use this information to construct my measures of client status.

The principal extension variable used below is a dummy that equals one for all plant year observations for years greater than or equal to the year the plant first participated in extension and zero otherwise.[9] That is $Ext_{it} = 1$ if plant i is or was a

[8] An exception is Nexus Associates (1996) where measure of dosage are used.

[9] One might also like to investigate whether the impact of extension services on client productivity varies according to the "dosage" received. Thus, one could use measures of intensity of the projects (e.g., hours of

client in years s#t. I also construct a series of dummies (described below) that measure time relative to when plants receive extension services. All of these measures vary over time, whereas those used in previous studied did not.

Within the framework given by equation (1), I estimate the impact of extension services on both labor and total factor productivity (TFP). Labor productivity is defined as real value added[10] per worker. TFP is defined in the conventional way as

$$TFP_{it} = \frac{Y_{it}}{K_{it}^{\beta_i} L_{it}^{\eta_i} M_{it}^{\gamma_i}}. \qquad \textbf{(2)}$$

The weights in the TFP calculation are coefficients from the regression of log(Y) on log(K), log(L) and log(M).

A. Descriptive Results

Table 1 provides summary statistics for the main variables used in the analysis below. The plants identified as clients are, on average, larger and more productive than nonclient plants. Also included in the table are some descriptive statistics on the treatments received by a subset of client plants for which such data are available. These numbers are

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extension center time, project related investments and so on) rather than dummy variables indicating client status. Unfortunately, I do not have comparable data on variables of this type from all the centers.

[10] Real value added is measured as shipments adjusted for changes in inventories and deflated minus deflated materials and energy costs.

computed from what the centers report as the combined center and client resources used for individual projects. Table 1 lists both average annual project costs and the average total project costs incurred at client plants in the 1987 to 1993 period. Comparing the magnitude of the resources associated with extension projects obtained from the client records to the levels of capital investment at client plants obtained from the LRD shows that these projects are relatively small. On average, the annual value of extension projects are around 3% of the value of capital investment at client plants.

Figure 1 shows the timing of the services received by the extension clients examined in this paper. Just over half of the clients participated in manufacturing extension before 1990 and 90% had been served by 1992 (by definition, all had been served by 1993). Given figure 1, if we were to observe most of the performance improvement at client plants occurring towards the beginning of this period, we would seriously question whether extension services had any role.

Figures 2 and 3 show how the productivity performance of client plants relative to 4 digit SIC industry averages evolved over the period from 1987 to 1993. Figure 2 depicts the relative level and the one and three year growth rates of labor productivity and figure 3 provides the same information for TFP. In both cases we see that, on average, client plants move up their industry productivity distributions over this time period. Further, most of this change occurs after 1990 and, thus, is at least consistent with a positive impact of manufacturing extension services. It also appears that productivity growth rates increase relative to industry averages over this period especially for labor productivity.[11]

Finally, figure 4 show how client plant characteristics change relative to when they receive extension services. Client plant characteristics are measured as percent deviations from plant means, after sweeping out state-industry-year effects, from two years prior to receiving services until two years after. The included characteristics are value added per worker, TFP, investment and employment.

The most striking feature of figure 4 is the increase in investment at client plants in the years during and immediately after participating in manufacturing extension. Labor productivity is also up sharply in the year after taking part in the program. This increase appears to be short lived. However, most client plants had not completed their participation in the program before the end of 1991. This implies that most do not have any valid observations for two years after participation. The results for two years after apply to a subset clients and may

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[11] Note that, since a large number of small plants are missing from the panel in 1988, the peaks in the one year growth rates (1st differences) and the troughs in the one and three year growth rates at 1989 and 1990, respectively, are outliers.

$$\log(TFP)_{it} = \alpha_{it} + \delta Ext_{it} + \varepsilon_{it} \tag{4}$$

not accurately represent all client plants and , therefore, should be viewed with caution.

B. Econometric Models

To more rigorously test whether extension services had any impact on the improved relative performance of client plants, I estimate several regressions, all of which are variants of the following two models

$$\log(\frac{VA}{L})_{it} = \alpha_{it} + \delta Ext_{it} + \beta \log(\frac{K}{L})_{it} + (\mu - 1)\log(L)_{it} + \varepsilon_{it} \tag{3}$$

where the intercept term for both models can be written as

$$\alpha_{it} = \alpha + \sum_{\tau=1}^{7} \rho_{\tau} Year^{\tau}_{it} + \sum_{j} \theta_{j} IND^{j}_{i} + \sum_{s=1}^{3} \phi_{s} State^{s}_{i} + \sum_{\tau}\sum_{j}\sum_{s} \xi^{\tau js} Year^{\tau}_{it} IND^{j}_{i} State^{s}_{i} \tag{5}$$

to control for year, industry and state effects. The parameter, *, on the extension variable (Ext) measures the impact of extension services on productivity.

One of the main concerns in trying estimate the program impact parameter, *, is that

unobserved variables that influence productivity, such as managerial quality, may be correlated with client status (i.e.,

$E(Ext_{it}g_{it})…0)$. In this case, estimates of program impact may be biased. By making assumptions about the nature of the unobserved variables, it is possible to estimate selection bias free program impact parameters. In this situation, researchers often assume that the error term in equations, such as (3) and (4), has both permanent and transitory components such that $g_{it} = g_i + :_{it}$ where $E(:_{it}) = 0$ and $E(Ext_{it}:_{it}) = 0$. The permanent component controls for plant fixed effects. In the current setting, this assumption is equivalent to assuming that unobserved time invariant plant characteristics, such as managerial quality, are the source of the selection bias. Namely, plants with high quality, aggressive management are more likely to participate in programs such as manufacturing extension.

Given this error structure, unbiased estimates of the program impact parameter, *, can be obtained by using fixed effect estimators. Below I estimate a number of fixed effect models of (3) and (4) using within, difference and growth rate estimators.

IV. EMPIRICAL RESULTS

In this section, I discuss the results of several regressions estimating the models given in equations (3) and (4). Tables 2 through 5 list estimates from level, within and difference specifications. Table 6 contains results from growth rate specifications and table 7 lists estimates from regressions that compare the timing of performance improvements relative to participation in the program.

A. Basic Regressions

Tables 2 through 5 contain a variety of specifications of the basic models in equation (3) and (4). Table 2 provides estimates from OLS regressions on the levels of the two models, whereas tables 3 through 5 provide within and difference estimates. In all these regressions, the extension variable is a dummy that equals one if the plant is currently, or has been, an extension client and zero otherwise. Notes at the feet of the tables explain the specification of each regression in more detail. The discussion here will focus on the estimates of the coefficient, *, on the extension variable.

The level and one year difference estimates (tables 2 and 4) suggest that manufacturing extension did not affect the labor or total factor productivity of client plants. However, the within and three year difference results indicate the extension does have an impact on labor productivity. These estimates suggest that value added per worker is between 2.5 and 5.9% higher for plant/year observations occurring after participation in manufacturing extension than it is for plant/year observations for nonclients and clients prior to participation.

The high estimate comes from a regression where the extension variable is interacted with year dummies. That is, I control for the year(s) in which extension services were received.

Controlling for the year that extension services were provided typically increases the estimated impact of extension. In general, the pattern on these interaction terms suggests that services received in the last few years of the period have a larger impact. This may be consistent with learning by doing (i.e., providing better assistance as the cumulative number of projects increases) at the extension centers. To save space, I do not report the estimated coefficients on these interaction term as they are typically imprecisely estimated and are not the focus of this paper.

The results from the level regressions, in table 2, indicate that plant year observations for clients after participating in the program are no more productive that those for nonclients and clients prior to participation. These results show that the higher productivity of client plants observed in table 1 disappears after controlling for other factors.

The results from the one year difference regressions in table 4 are difficult to interpret. Taking differences can decrease the signal to noise ratio and bias coefficient estimates towards zero (see Griliches and Hausman, 1986). Taking longer differences can help alleviate the problem. Indeed, the three year difference estimates of program impact in table 5 are higher than the one year difference estimates in every case.

Another reason that difference estimators, particularly in the case of one year differences, are problematic in this case is due to the nature of the extension variable. Recall that the extension variable is a dummy that is set to one in the first period that a plant becomes an extension client and in all subsequent periods and is zero otherwise. That is, in level comparisons, the estimate of * measures the mean difference between client plants after receiving extension services and all plants prior to receiving services. The comparison group contains both plants that are never clients during the period under study and those plant/year observations for client plants prior to participation in extension programs. In the difference specification, the estimate of the extension variable measures the impact of the change in client status on the change in productivity. Given its definition, there is much less variation left in the extension variable after differencing than there was before. This is especially true in the case of one year differences. For example, take the case of plant that participates in the program in 1990. The level extension variable for such a plant would equal one from 1990 on, and zero otherwise. The one year difference of the extension variable is non-zero for only one year (Ext_{i90}-Ext_{i89}=1).

In all the regressions in tables 2 through 5, the estimated impact in TFP is much smaller than that for labor productivity and it is never statistically significant. This due, most likely, to measurement error in materials. One could alternatively define TFP as the ratio of value added to capital and labor, appropriately weighted. In regressions not reported here, I estimate the impact of extension on the value added definition of TFP and found results very similar to the labor productivity results.

B. Growth Rate Regressions

While policymakers may be interested in how the change in client status effects productivity growth, they are probably more interested in how client status itself impacts productivity growth. That is, they would like to know if productivity growth is higher at client plants after they have participated in manufacturing extension. To examine this issue, I slightly alter the specification of the difference estimators in tables 4 and 5 by replacing the differenced extension variable with the level extension variable (e.g., I use Ext_{it} rather than $Ext_{it}-Ext_{it-1}$).

Results from these growth rate regression are listed in table 6. The extension variable here measures the percent difference between the rate of productivity growth at client plants after they participated in the program, and that of all plants before participation. Statistically and economically significant impacts are found for the three year growth rate of labor productivity and the one year growth rate of TFP. Economically important but statistically insignificant impacts are estimated for annual labor productivity growth and three year TFP

growth. Thus, productivity growth is enhanced at plants that have participated in manufacturing extension.

C. Timing Regressions

One of the key advantages to the longer panel used in this study is increased flexibility in specifying the extension variable. Concern about selection issues pervades the program evaluation literature. The various difference, within and growth rate regressions used so far are ways to take advantage of panel data to control for selection problems. Another way to exploit panel data to control for selection bias involves specifying the program participation variable(s) to estimate baseline magnitudes of productivity or productivity growth at client plants. The idea is that, if the estimated extension variable in equations (3) and (4) is positive simply because superior performing plants self select into the program, then putting in dummies for client plants for the years immediately before their participation in the program should sweep this effect out. If the estimated coefficients on these dummies are positive and significant, then we have evidence that client plants were performing better than nonclients even before they participated in the program.

The first, second, fifth and sixth columns of Table 7 contain regressions where this is done. The variables One and Two Years Prior are dummies for client plants one and two years, respectively, before they participated in manufacturing extension. The regressions use the within specification with dummies for state-industry-year (interacted) effects. The estimates on the one and two year prior variables are positive in three of the four case, but never significantly different from zero. The coefficient on the extension variable still indicates positive and significant impacts of program participation on labor productivity. The estimated impact on TFP is also positive but measured imprecisely.

Finally, I exploit the panel data even further by looking at the performance of client plants before, during and after participation in manufacturing extension. Recall that figure 4 indicated that client plants appear to investment more in the years during and immediately after receiving extension services and that labor productivity is higher one year after receiving services. Table 7 contains results that are qualitatively similar to the situation depicted in figure 4.

The impact is concentrated in the years during or the year immediately after participation. Unfortunately, only just over a third of the 726 client plants included in this analysis had any observations two or more years after participating in manufacturing extension programs. Therefore, one should view the results suggesting that the impact of extension services on the productivity of client plants is short lived cautiously . More rigorous testing of the duration of the effect on extension services must wait until a longer panel can be assembled. Nevertheless, the main result to take away from the regressions in table 7 is that the extension clients perform better in the periods during and after receiving extension services. This finding is, at least, consistent with the notion that these services help plants become more productive.

V. CONCLUSIONS

Evaluating the impact of programs, such as manufacturing extension, with nonexperimental data is difficult. Appropriate data are typically scarce and what data there are usually do not cover the entire program. Thus, it is unlikely that any one study can provide definitive evidence of program effectiveness, or the lack of it. This paper is no exception.

In this paper, I used a balanced panel of extension clients and a control group of nonclient plants to explore two weaknesses of previous empirical work in this area. First, I assessed the robustness of previous estimates of program impact using a variety of fixed effects and growth rate estimators. Then, I examined the timing of performance improvements at client plants relative to when they received extension services to see if it is reasonable to infer that program participation played a role.

The main conclusions from the analysis above are the following. i) Estimated program impacts are sensitive to model specification. Positive program impacts on labor productivity are found for the within, three year difference and three year growth rate specifications. ii) The estimated impact on TFP is smaller than that for labor productivity and is statistically significant only in only a couple regressions. However, as was pointed out in the text, this is due mostly to measurement problems with materials. iii) The range of estimates for program impact in this analysis is similar to those obtained in previous studies. This suggests that selection bias in previous estimates may not be too severe. iv) Finally, the results in table 7 and figure 4 provide very compelling evidence that the timing of performance improvements is consistent with positive impacts of participating in manufacturing extension.

However, some interesting outstanding issues remain for future studies. First, some of the estimates suggest that the benefits to client plants of participating in extension can be quite large. Just doing some rough calculations suggests that an increase in labor productivity at client plants of 2.5%, after extension, will lead to an average increase in value added of just over $270,000. Given what we know about the magnitude of the investments in extension projects, this suggests returns greater than 2 to 1[12]. Higher estimates imply even higher returns. The estimates of program impact reported in this paper are similar in magnitude to those found in previous studies and the implied returns have been cited in case studies (see NIST, 1997). However, is it appropriate to attribute all the performance improvements observed at client plants to program participation when the extension projects account for only a small portion of investment at these plants? Perhaps the best way try to sort out the impact of extension from other productivity enhancing activities at client plants is to replace the dummy client indicators used here and in most other studies with continuous project dosage measures. This would allow researchers to obtain estimates of the value of another dollar devoted to extension, rather than the value of being a client. Such a dataset is not currently available, but should be within a couple of years.

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[12] From table 1, an increase in log(VA/L) of 2.5% leads to an increase in VA/L of $1339. At a plant with 202 workers (the geometric mean) this implies an increase in VA of $271,218. The range of investment comes from the $107,096 reported by a subset of centers to $142,162 which combines the non-client financed portion ($64,041) reported by the centers plus the estimated increase in client investment from figure 4 (6.2% in active year(s) and 8% in the years after participation) which works out to approximately $78,758.

Second, more work needs to be done to determine how long the benefits of participation in manufacturing extension programs persist. There is some very weak and preliminary evidence here that suggests that the benefits, while large, do not extend beyond one year after the receipt of services. A longer panel is needed, however, before we can reliably assess the duration of program impacts.

Table 1
Descriptive Statistics
(Means by Client Status)

	Clients	Nonclients
Number of Plants	726	5818
Number of Obs	4859	38589
Shipments	$60,722†	$45,178†
Value Added (VA)	$29,668†	$20,887†
log(VA)	9.318	8.748
Total Employment (L)	358.8	256.6
log(L)	5.311	4.762
Capital Stock (K)	$24,459†	$18,350†
log(K/L)	3.622	3.587
Materials and Energy (M)	$31,054†	$24,290†
log(M/L)	3.832	3.941
Investment	$2,182†	$1,435†
log (Investment)	6.282	5.620
Annual Project Costs	$67,908††	-
log(Annual Project Costs)	9.391	-
Total Project Costs	$107,096††	-
log(Total Project Costs)	9.854	-
log(VA/L)	4.008	3.984
log(TFP)	2.204	2.216

Notes: Data are from the LRD (Annual Survey of Manufactures). Shipments are adjusted for changes in inventories and deflated using 4 digit SIC NBER deflators. Materials and energy is the sum of the cost of parts and materials, the cost of resales and the cost of contract work all deflated by 4 digit NBER materials deflators, plus the sum of the cost of fuels and electricity deflated by 4 digit NBER energy deflators. The capital stock is computed using the book value of machinery and structures in 1987 and annual data on investment in new and used machinery and structures (deflated by 4 digit NBER investment deflators) to compute stocks from 1988 to 1993 using the perpetual inventory method, where the depreciation rate in assumed to be the average of the reported depreciation rates for each plant in 1987 and 1992 (i.e., for each year the depreciation rate equals total depreciation divided by total book value). Value added is real shipments less real materials and energy. TFP is computed as shown in the text.

† denotes values x$1000 (1992 values).
†† Data of project costs are available for 399 client plants from 7 of the 9 centers. The reported "project costs" are the sum of i) provider costs including

cash grants or loans provided by the center, ii) center personnel costs, iii) inkind outlays by the client, iv) client fees and v) client investments in plant, equipment and training. Annual costs reflect the costs of all projects done at a plant in a given year. Total costs are the costs of all projects done a plant in the 1987-1993 period.

Table 2
Level Regressions

Dependent Variable	Log(VA/L)			Log(TFP)		
Ext.	-.003	-0.017	0.011	-0.014***	-0.016**	-0.006
	(0.014)	(0.013)	(0.025)	(0.007)	(0.007)	(0.013)
Log(K/L)	0.368*	0.263*	0.263*			
	(0.003)	(0.004)	(0.004)			
Log(L)	-0.002	0.011*	0.011*			
	(0.003)	(0.003)	(0.003)			
Dummies	No	Yes	Yes	No	Yes	Yes
Ext*Year	No	No	Yes	No	No	Yes
N	42560	42600	42600	43060	43060	43060
D.F.	42596	42148	42142	43059	42610	42608
R^2	0.241	0.386	0.386	0.0001	0.212	0.212

Notes: Ext_{it} = 1 if plant i is a client in periods s#t and 0 otherwise. Dummies include state, 4 digit SIC industry and year. The models estimated are given in equations (3) and (4).

Table 3
Within Regressions

Dependent Variable	Log(VA/L)			Log(TFP)		
Ext.	0.025***	0.026	0.059*	-0.003	0.002	0.016
	(0.014)	(0.020)	(0.026)	(0.007)	(0.009)	(0.013)
Log(K/L)	0.052*	0.179*	0.179*			
	(0.010)	(0.009)	(0.009)			
Log(L)	-0.185*	-0.018**	-0.018**			
	(0.012)	(0.009)	(0.009)			
Dummies	No	Yes	Yes	No	Yes	Yes
Ext*Year	No	No	Yes	No	No	Yes
N	42600	42600	42600	43060	43060	43060
D.F.	36065	28821	28815	36225	29283	29277
R^2	0.745	0.792	0.792	0.695	0.743	0.743

Notes: Ext_{it} = 1 if plant i is a client in periods s#t and 0 otherwise. All variables are measured as deviations from plant means (e.g., $X'_{it} = X_{it} - X_{i\cdot}$). Dummies are year and (state)*(4 digit SIC industry)*year. When dummies are included, the estimation procedure first takes all time varying variable and subtracts the state*industry*year means and then differences are computed.

Table 4
One Year Difference Regressions

Dependent Variable	Log(VA/L)			Log(TFP)		
Ext.	-0.016 (0.020)	-0.021 (0.022)	0.006 (0.070)	-0.004 (0.010)	-0.009 (0.011)	-0.002 (0.034)
Log(K/L)	-0.012 (0.019)	0.249* (0.011)	0.249* (0.011)			
Log(L)	0.334* (0.021)	-0.027* (0.010)	-0.027* (0.010)			
Dummies	No	Yes	Yes	No	Yes	Yes
Ext*Year	No	No	Yes	No	No	Yes
N	33580	33435	33435	34081	34081	34081
D.F.	33576	27235	27230	34709	27883	27878
R^2	.023	0.031	0.031	0.00001	0.001	0.001

Notes: Ext_{it} = 1 if plant i is a client in periods s#t and 0 otherwise. All variables are measured as one year differences (e.g., $X'_{it} = X_{it} - X_{it-1}$). Dummies are year and (state)*(4 digit SIC industry)*year. When dummies are included, the estimation procedure first takes all time varying variable and subtracts the state*industry*year means and then differences are computed.

Table 5
Three Year Difference Regressions

Dependent Variable	Log(VA/L)			Log(TFP)		
Ext.	0.028***	0.028	0.037	0.0001	-0.001	0.0002
	(0.017)	(0.019)	(0.039)	(0.009)	(0.010)	(0.019)
Log(K/L)	0.037*	0.171*	0.171*			
	(0.013)	(0.010)	(0.010)			
Log(L)	-0.199*	-0.036*	-0.036*			
	(0.016)	(0.011)	(0.011)			
Dummies	No	Yes	Yes	No	Yes	Yes
Ext*Year	No	No	Yes	No	No	Yes
N	23084	23044	23044	23505	23505	23505
D.F.	23080	18826	18823	23503	19289	19286
R^2	0.020	0.023	0.023	0.000	0.0002	0.0005

Notes: Ext_{it} = 1 if plant i is a client in periods s#t and 0 otherwise. All variables are measured as three year differences (e.g., $X'_{it} = X_{it} - X_{it-3}$). Dummies are year and (state)*(4 digit SIC industry)*year. When dummies are included, the estimation procedure first takes all time varying variable and subtracts the state*industry*year means and then differences are computed.

Table 6
Growth Rate Regressions

Dependent Variable	Log(VA/L)				Log(TFP)			
	One Year		Three Year		One Year		Three Year	
Ext.	0.007	0.034	0.033**	0.057***	0.001	0.019***	0.001	0.018
	(0.011)	(0.023)	(0.015)	(0.029)	(0.006)	(0.011)	(0.007)	(0.014)
Log(K/L)	-0.013	0.249*	0.037*	0.170*				
	(0.019)	(0.010)	(0.013)	(0.010))				
Log(L)	-0.335*	-0.027*	-0.199*	-0.037*				
	(0.016)	(0.010)	(0.016)	(0.010)				
Dummies	No	Yes	No	Yes	No	Yes	Yes	Yes
Ext*Year	No	Yes	No	Yes	No	Yes	No	Yes
N	33580	33435	23084	23044	34081	34081	23505	23505
D.F.	33576	27230	23080	18823	34079	27878	23503	19286
R^2	0.023	0.031	0.021	0.023	0.000	0.001	0.000	0.0004

Notes: Ext_{it} = 1 if plant i is a client in periods s#t and 0 otherwise. All variables are measured as either one or year differences, or growth rates since all continuous variables are measured in logs (e.g., $X'_{it} = X_{it} - X_{it-1}$), with the exception of Ext which is not differenced. Dummies are year and (state)*(4 digit SIC industry)*year. When dummies are included, the estimation procedure first takes all time varying variables and subtracts the state*industry*year means and then differences are computed.

Table 7
Timing Regressions

Dependent Variable				Log(TFP)				
Ext.	0.048**	0.079*			0.004	0.018		
	(0.024)	(0.030)			(0.012)	(0.015)		
Two Years Prior	0.030	0.004	0.024	0.010	0.002	-0.001	0.002	0.004
	(0.029)	(0.078)	(0.028)	(0.079)	(0.014)	(0.040)	(0.014)	(0.040)
One Year Prior	0.034	0.025	0.027	0.031	0.003	-0.012	0.003	-0.007
	(0.029)	(0.078)	(0.028)	(0.078)	(0.014)	(0.039)	(0.014)	(0.040)
Active			0.032	0.098**			0.006	0.037***
			(0.024)	(0.046)			(0.013)	(0.021)
One Year Post			0.070**	0.084**			0.011	0.022
			(0.030)	(0.041)			(0.015)	(0.021)
Two Years Post			0.028	0.035			-0.016	-0.015
			(0.039)	(0.059)			(0.019)	(0.030)
Log(K/L)	0.168*	0.168*	0.168*	0.168*				
	(0.009)	(0.009)	(0.009)	(0.009)				
Log(L)	-0.034*	-0.034*	-0.034*	-0.034*				
	(0.010)	(0.010)	(0.010)	(0.010)				
Ext*Year	No	Yes	No	Yes	No	Yes	No	Yes
N	42600	42600	42600	42600	43060	43060	43060	46060
D.F.	28819	28804	28817	28793	29281	29277	29279	29255
R^2	0.792	0.792	0.792	0.792	0.743	0.744	0.743	0.744

Notes: Ext_{it} = 1 if plant i is a client in periods s#t and 0 otherwise, (Two Years Prior)$_{it}$ = 1 if plant i will be a client two years from year t, (One Year Prior)$_{it}$ = 1 if plant i will be a client one year from year t, (Active)$_{it}$ = 1 if plant i is a client in year t, (One Year Post)$_{it}$ = 1 if plant i was a client one year before year t, (Two years Post)$_{it}$ = 1 if plant i was a client two year before year t. All variables are measured as deviations from plant means (e.g., $X'_{it} = X_{it} - X_{i@}$). All regressions include dummies for year and (state)*(4 digit SIC industry)*year. When dummies are included, the estimation procedure first takes all varying variable and subtracts the state*industry*year means and then differences are computed.

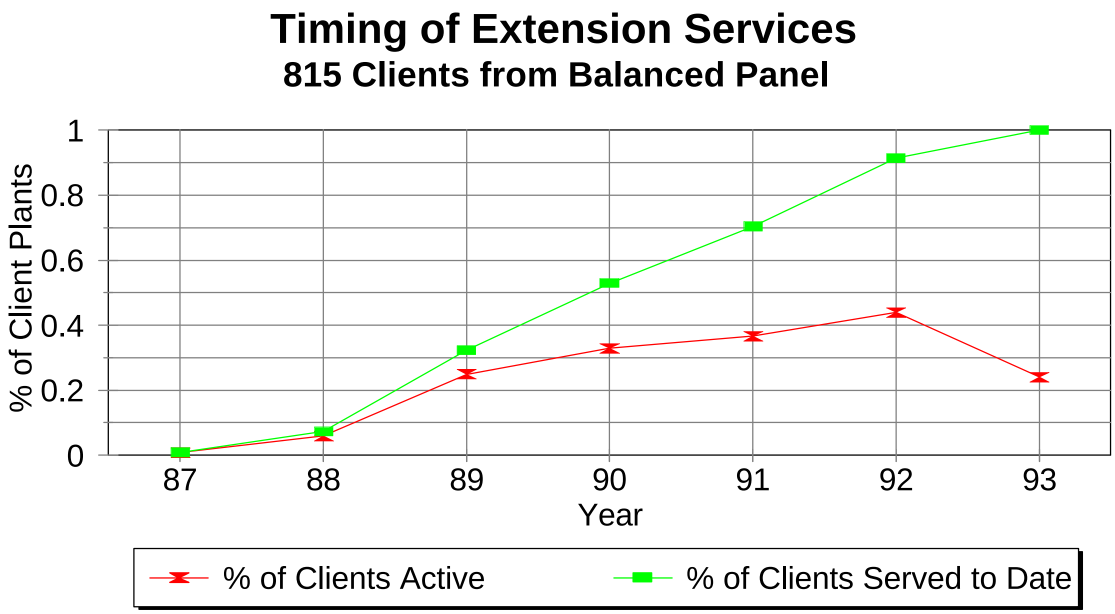
Timing of Extension Services
815 Clients from Balanced Panel
% of Client Plants
1
0.8
0.6
0.4
0.2
0
87
88
89
90
91
92
93
Year
% of Clients Active
% of Clients Served to Date

Figure 1

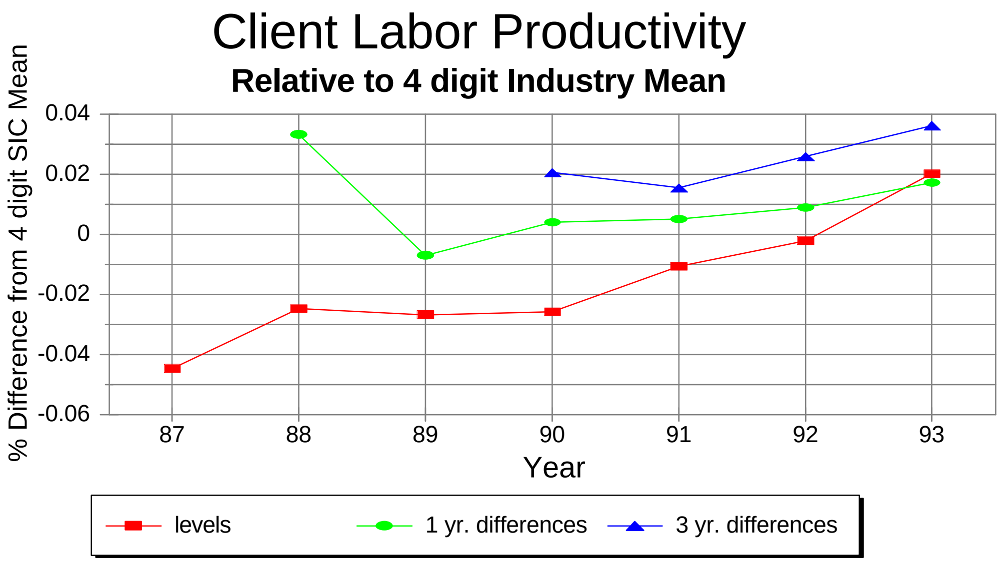
Client Labor Productivity
Relative to 4 digit Industry Mean
% Difference from 4 digit SIC Mean
0.04
0.02
0
-0.02
-0.04
-0.06
87
88
89
90
91
92
93
Year
levels
1 yr. differences
3 yr. differences

Figure 2

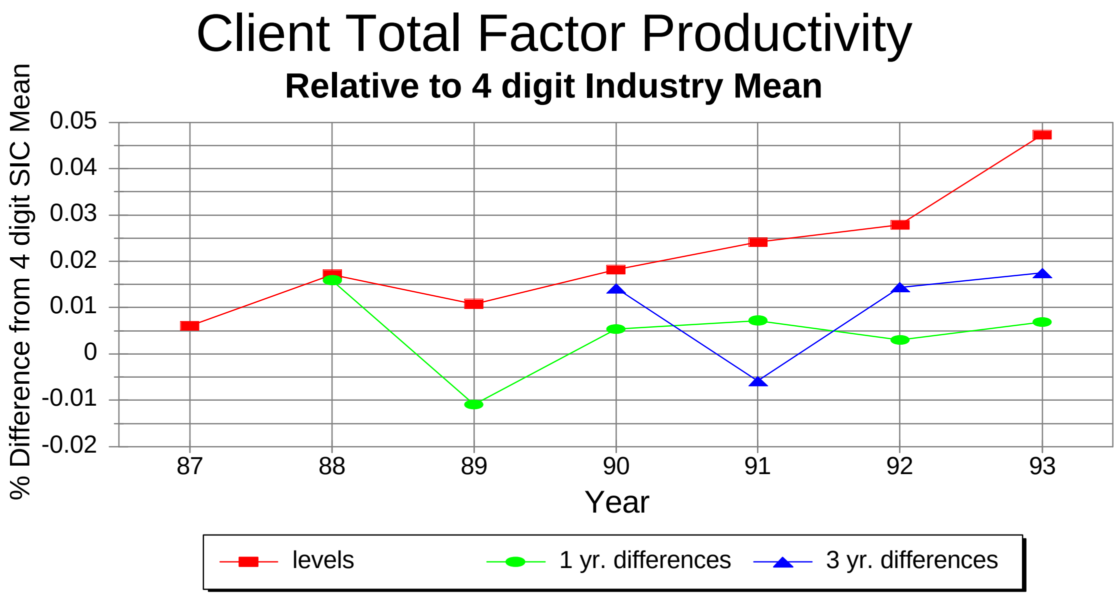
Client Total Factor Productivity
Relative to 4 digit Industry Mean
% Difference from 4 digit SIC Mean
0.05
0.04
0.03
0.02
0.01
0
-0.01
-0.02
87
88
89
90
91
92
93
Year
levels
1 yr. differences
3 yr. differences

Figure 3

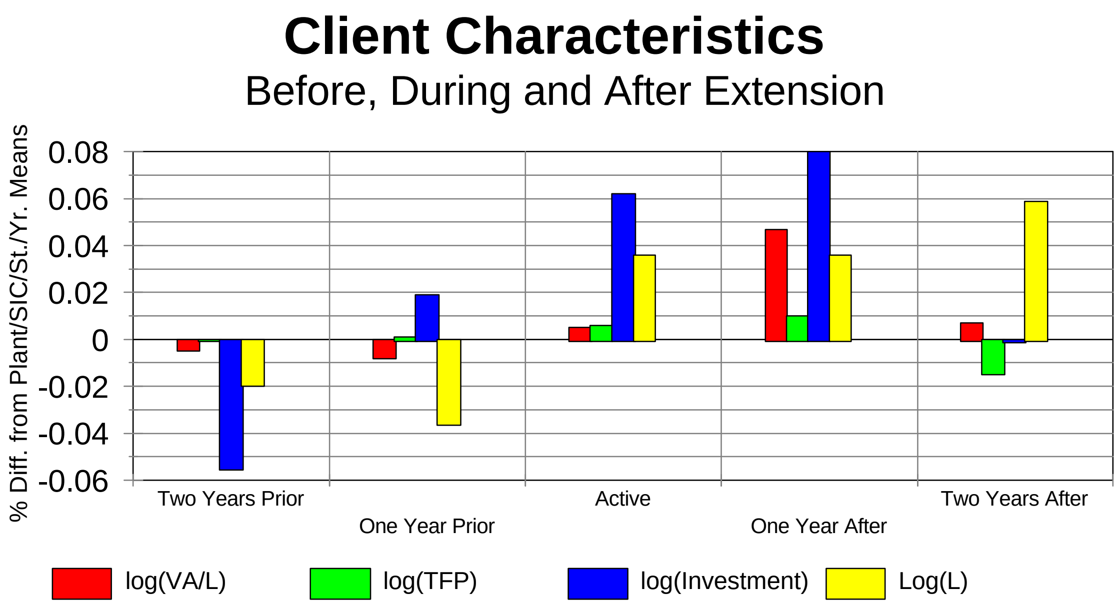

Figure 4

Notes: Means are for all client plants relative to plant, industry, state and year means. Active represents the year(s) in which client plants participate in the program, two years prior is the year two years prior to participation and so on (see the notes after table 7 for more details). The mean values for the characteristics given above are computed as follows,

$$\overline{X''_{\tau}} = \frac{1}{N_c}\sum_{i \in C} X''_{i\tau} \qquad \textit{(mean value for client plants shown in the figure)}$$

where J = {two year prior, one prior, active, one year after, two years after}, C is the set of and N_c is the number of client plants, and

$$X''_{it} = X'_{it} - X'_{i\cdot}$$

where

$$X'_{it} = X_{it} - \frac{1}{N_{k_t}}\sum_{j \in K_t} X_j$$

where K_t is set of all (client and nonclient) plants in plant i's state and four digit SIC industry in year t.

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